SHORT-TERM VISUOSPATIAL MEMORY IN SENILE DEMENTIA OF THE ALZHEIMER TYPE

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ABSTRACT

Baddeley's (1990) Working Memory model was used as a theoretical basis to examine the acquisition and retention of visual patterns in older adults with senile dementia of the Alzheimer type (SDAT) and in age-matched controls. To assist with diagnosis the CERAD screening and Neuropsychological Battery was administered to the 8 patients (CDR = 0.5 to 1.0) and 8 controls (CDR = 0). Various distractor ("interference") conditions were used during the delay period prior to recall. In addition to a zero second delay condition, no distractor, a visual distractor, an auditory distractor and a central executive system (CES) distractor was used during either a 3 second or 12 second delay interval. The forced choice delayed matching-to-sample computer task revealed lengthening response latencies across distractor conditions for SDAT subjects, but not controls. SDAT subjects correctly recognised fewer patterns than controls, especially as the delay interval increased. These findings concur with Baddeley and Morris's (Morris & Baddeley, 1988; Morris, 1994) claims that the CES is differentially impaired in early SDAT, as any subsidiary task concurrent with maintenance rehearsal caused a decrement in performance in the patient group.

CHAPTER ONE

INTRODUCTION

Short-term/working memory loss is one of the early symptoms of Senile Dementia of the Alzheimer Type (SDAT), but while there have been many studies using verbal material few studies have examined memory for visual or spatial patterns. The purpose of this study was to use Baddeley's (1990) working memory model as a theoretical basis to examine the acquisition and retention of visual patterns in patients with dementia of the Alzheimer type and in age-matched controls, using various distractor ("interference") conditions during a delay period prior to recall. This study provides further information on working memory in SDAT patients, an aspect that is becoming increasingly topical in cognitive neuropsychology (Della Sala & Logie, 1993).

GENERAL IMPAIRMENTS IN SDAT

Biological Markers

Senile Dementia of the Alzheimer type (SDAT) is a neurodegenerative disorder of insidious onset, which is characterized by a global and progressive deterioration of memory, attention, cognition and personality, resulting from widespread cortical and subcortical neuronal loss (Salmon et al, 1989). The presence of neuropathological markers such as granulovacuolar degeneration, neurofibrillary tangles (intraneuronal lesions consisting of a mass of insoluble cytoskeleton proteins) and neuritic plaques (complex neuropil alterations of amyloid protein deposits often accompanied by glial cells and dystrophic neurons) can only be confirmed at autopsy (Hyman et al, 1993). Histological investigations have found a concentration of neurofibrillary tangles in 'specific cytoarchitectural areas and lamina that give rise to projections from the entorhinal cortex, the hippocampal formation and the amygdala' while the terminal zones of many of these projections contained neuritic plaques and amyloid protein deposits (Hyman et al, 1990). Fewster et al (1991) suggested that 'the neurofibrillary tangle formation affects the Alzheimer brain in the following sequence: hippocampus; then temporal neocortex; then frontoparietal and cingulate, and lastly, sensorimotor and visual areas.' Positron emission tomography (PET) studies show decreased cortical metabolic activity, particularly in the parietal cortex in the early stages of the disease, (Chase et al 1995) spreading to the frontal and temporal associative cortex as the disease progresses (Perani et al, 1993). Magnetic Resonance Imaging (MRI) scans typically show enlarged ventricles and widened lateral fissures and sulci (Morris, 1994a). Electroencephalographic (EEG) studies show a breakdown in physiological connectivity between brain regions with reduced coherence in areas linked by dense bands of long corticocortical fibres (Leuchter et al, 1992). From the neurochemical perspective, the principal dysfunction is a decrease of cholinergic activity in neocortical and hippocampal regions (Carlesimo et al, 1992) which is related to the degree of dementia (Money et al, 1993). Glutamate and somatostatin levels are also reduced in these areas while other neurotransmitters (eg., norepinephrine and serotonin) appear normal or only slightly reduced (Carlesimo et al, 1992).

Single photon emission computerized tomography (SPECT) studies of regional cerebral blood flow (rCBF) in SDAT patients show a specific association of reduced right parietal rCBF ratios with visuospatial performance (Eberling et al, 1993)

Neuropsychological Indications

Although the normal elderly may notice a subtle episodic memory decline with increasing age, the memory deficits associated with SDAT are of greater magnitude and involve aspects of memory that are relatively spared by aging (Butters et al, 1994). "Recent memory" loss (episodic or event memory) and an impairment in the organisation of semantic memory (word finding difficulties) are usually the earliest and most prominent features of SDAT, followed by problems with abstract reasoning and complex attention, then by impairments in visuospatial abilities (Zec, 1993) such as figure ground perception (Mendez et al, 1990). However patterns of deficits are heterogenous with some patients exhibitting specific deficits related to one domain (eg., word finding difficulties but intact spatial and constructional skills) while other patients exhibit the reverse pattern (Martin, 1987; Baddeley et al, 1991b).

Explicit measures of memory loss for both verbal and visual material, using overt recall or recognition, require conscious recollection of information, while implicit measures of memory, such as priming or skill acquisition, may exert influence on ongoing behaviour without conscious recollection of the information (Carlesimo & Oscar-Berman, 1992). On explicit memory measures, SDAT patients show deficits in both serial recall and free recall for both verbal and non-verbal material (Dannenbaum et al, 1988). SDAT patients also show deficits in iconic memory, a large-capacity, fast decaying temporary register of perceptual information, some of which may be passed to working memory to be used as information for conscious decision making (Deary, Hunter, Langan & Goodwin, 1991). Deficits in acquisition, encoding, storage and retrieval have also been found in SDAT patients (see Carlesimo & Oscar-Berman, 1992 for a review). Implicit memory measures involving skill learning such as a pursuit rotor task (Baddeley, 1990), mirror reading (Deweer et al, 1993) or mirror drawing show that SDAT patients can learn as well as normal controls, while priming studies show that SDAT patients are impaired when the procedure involves lexical-semantic properties (Bondi & Kaszniak, 1991) but are less impaired when the tasks rely on the analysis of perceptual configurations (Carlesimo et al, 1992). Personal memories for remote events are relatively intact in the early stages of SDAT (Mitrushina et al, 1994), but deteriorate with disease progression (Whitehouse et al, 1993), while memory for famous faces or events is impaired from an early stage (Morris, 1991).

Although SDAT patients do not suffer from impairments of consciousness and remain alert, they may suffer deficits in selective attention. Reaction time tests, particularly those with a choice component, show abnormal slowing relative to age matched controls (Gordon & Carson, 1990). Decision making processes are slowed by SDAT even in very mildly demented patients (Pate et al, 1994).

There is also a marked impairment in short-term memory tasks which involve divided attention, some reduction in verbal and non-verbal memory span, but only a small decrement in the recency component of short-term memory (Morris, 1994b). Recent interest in short-term memory in SDAT has focussed on establishing whether this pattern of deficits can be accommodated by the working memory model (Baddeley, 1990).

THE WORKING MEMORY MODEL

Baddeley's influence on the investigation of STM has been to extend the traditional concept of primary / short term memory to that of a more complex information processing, working memory system. Working Memory is a system that provides concurrent temporary storage and manipulation of the information necessary for complex cognitive tasks, such as language comprehension, learning and reasoning (Baddeley, 1992c). The system comprises an attentional controller, called the central executive system (CES), and two active slave systems, the phonological loop (PL), which maintains speech based information, and the visuospatial sketch pad (VSSP), which holds and manipulates visuospatial information. The main characteristics of the components of the Working Memory model are briefly described below before discussing specific WM deficits in senile dementia of the Alzheimer type .

Central Executive System (CES)

The CES is the most important and complex component of WM, but also the least well understood. The actual nature and function of the CES is still unclear. It is presumed to be a highly integrated system, with limited processing capacity, which initiates, co-ordinates and maintains processes and information that are active in working memory while allocating resources to them and deleting them when no longer needed (Schwartz, 1990). The CES has the capacity to selectively attend to one stimulus while inhibiting the disruptive effects of others and to switch retrieval strategies and modalities in response to changing conditions (Baddeley, 1996). Updating running memory is thought to occur by rapidly deploying these CES resources while also monitoring response output (Morris & Jones, 1990a), but the CES itself is not involved with storage (Baddeley, 1993). Thus some of the general functions of the CES include: supervising the activity of the working memory subsystems, co-ordinating information from different modalities, involvement in maintenance rehearsal by updating the memory trace in the PL and VSSP, retrieval from LTM and attentional control analogous to Norman and Shallice's (1986) supervisory attention system (SAS). The Norman and Shallice model assumes that most ongoing actions are controlled by automatic motor programmes (action schemata) which may be overridden by the SAS in novel or attention demanding situations (Shallice & Burgess, 1993). Although traditionally believed to be a frontal lobe system (Baddeley, 1996), recent PET studies also implicate the anterior cingulate and posterior parietal cortex during attention and orienting (Posner & Raichle, 1994).

The simultaneous storage and processing of information, including that from different modalities, is co-ordinated by the CES to facilitate performance of concurrent tasks. A frequently used dual task experiment is the Brown-Peterson task (Peterson & Peterson, 1959), in which subjects are required to remember trigrams of consonants in their correct order for varying short intervals while performing a concurrent subsidiary task, such as counting backwards by threes. Different aspects of the Brown-Peterson task can be varied, such as the retention interval, the type of distractor task and the number of items to be remembered. Putative impairments of the CES are demonstrated in such dual task experiments.

Phonological Loop

Much more attention has been focused on the two slave systems, particularly the phonological loop. The PL is assumed to be responsible for maintaining speech based information, such as digits or words, and is also implicated in language learning. The phonological loop is thought to have two components: a phonological store for holding acoustic or speech based information for 1-2 seconds; and an articulatory control process, which maintains material within the phonological store by subvocal repetition, and which converts visually presented words or nameable pictures by subvocalization for registration in the phonological store (Baddeley, 1992c). There have been many studies of the processes involved in the short term memory of verbal information. Two basic phenomena of interest in this regard are the phonological similarity effect (in which strings of similar, rather than dissimilar, sounding letters or words are more difficult to remember) which reflects the operation of the phonological store, and the word-length effect (whereby fewer multisyllable words are recalled than single syllable words) which reflects the speed of subvocal rehearsal by the articulatory control process (Baddeley & Hitch, 1994). The phonological loop has also been shown to be disrupted by articulatory suppression (repeatedly uttering a simple word or phrase) (Baddeley, Lewis & Vallar, 1984) and irrelcvant (unattended) speech and changing state non-speech sounds (Jones, 1995) although habituation reduces the irrelevant speech effect (Morris & Jones, 1990b).

Recent regional cerebral blood flow (rCBF) studies suggest that the phonological store is localized in the left supramarginal gyrus while the subvocal rehearsal system is associated with Broca's area (Paulesu, Frith & Frackowiak, 1993).

Visuospatial Sketchpad

The visuospatial sketchpad processes visuospatial information and internally generated visual imagery. It is also thought to be fractionated into two subsystems: one is a passive store that is principally concerned with the representation of visual pattern information processed by the occipital lobes; and a more active processing spatial component which also processes sequential information that depends more on the parietal lobes (Farah, 1988). This has been supported by neuropsychological evidence of double dissociations between visual tasks and spatial tasks (Farah and Hammond et al, 1988), and selective interference experiments (Tresch et al, 1993; Vecchi, Monticellai & Cornoldi, 1995). Recent PET studies by Smith & Jonides (1995) found that short term (3 seconds) spatial memory tasks led to activation in the right hemisphere occipital, parietal and prefrontal regions while short term object memory tasks led to activation in the left hemisphere parietal and prefrontal areas, indicating a possible verbal recoding of the stimuli.

Recent studies using matrix patterns have shown small but persistent error increases due to interference from a spatial tapping secondary task (Barton, Matthews, Farmer & Belyavin, 1995). Active visuospatial processing can be disrupted by passive exposure to irrelevant visual material, although disruption of the passive visual 'buffer' by a changing state visual distractor, analogous to the irrelevant speech which disrupts the phonological loop, may be necessary for visual interference to occur (Toms, Morris & Foley, 1994). The visual input is believed to have obligatory access to the VSSP causing interference during both encoding and maintenance rehearsal (Logie & Marchetti, 1991). Short term spatial order memory is interfered with by any task (visual, auditory, perceptual or motor) which also makes demands on spatial attention (Smyth & Scholey, 1994).

Little study has been done on visuospatial information because of the difficulty in finding stimuli that are not easily nameable or capable of verbal encoding, creating difficulty in ascertaining whether the visuospatial sketchpad alone is being employed or other subsystems are also aiding recall. Most studies have employed visual imagery tasks which have been shown to be disrupted by visual tracking, spatial arm movements, eye movement and presentation of irrelevant visual material during learning (Baddeley & Hitch, 1994). Morris (1987) concluded that the visuospatial sketchpad can operate independently of the phonological loop, but that central executive resources are required during encoding and retrieval operations, and that only minimal resources are needed during maintenance rehearsal. The nature of the rehearsal process is unclear (Baddeley,1992a), but one theory suggests that covert eye movements are involved in rehearsing or refreshing visuospatial location information, while mental images maintain object information (Logie, 1995). A recent study by Hale, Myerson, Rhee, Weiss and Abrams (1996) found that looking and pointing selectively interfered with spatial location memory, but mentally rotating visual stimuli or making colour or shape discriminations only interfered with spatial working memory if the response was visually guided, but not if the response was verbal.

WORKING MEMORY DEFICITS IN SENILE DEMENTIA OF THE ALZHEIMER TYPE

Some of the cognitive deficits exhibited by Alzheimer's patients have been suggested as resulting from attentional and/or encoding difficulties, an increased rate of memory decay, or because working memory processes responsible for maintenance rehearsal are dysfunctional. Impairments in both recognition and retrieval from long term memory may also be related to problems within Working Memory. The following is a summary of some recent studies of short-term memory in mild to moderate (not severe) SDAT that have used the Working Memory model as a theoretical framework.

Phonological Loop in SDAT

Impairments in verbal memory tasks, including STM tasks such as verbal memory span, are not due to impairments at the level of the phonological loop. The phonological similarity effect is undiminished in SDAT, suggesting that the phonological store is intact (Morris, 1984); an intact word-length effect (Morris, 1984), and evidence of normal rates of articulatory rehearsal, suggest unimpairment in the articulatory control process. These findings indicate that the Phonological Loop is functioning normally in early SDAT and that an impairment in the CES is possibly responsible for the reduction in memory span and related tasks. Recently Belleville, Peretz and Malenfant (1996) found a subgroup of SDAT patients who showed phonological loop deficits as well as CES deficits.

Visuospatial Sketch Pad in SDAT

Some standard VSSP tasks use visual imagery, but these tasks are too difficult for SDAT patients. In contrast to their mild verbal memory span deficit, SDAT patients show a moderate to severe reduction in their block span using the Corsi Block Span Test (Miller & Morris, 1993). Grossi, Becker, Smith and Trojano (1993) removed the order condition of the Corsi Block Test by requiring patients to mark on a response grid the black squares which they had viewed for 1 second per square (ie. 2 black squares = 2 seconds viewing). They found a defect in visuospatial memory span such that patients were impaired in their ability to reproduce the spatially patterned visual stimuli, even immediately after presentation. In an extension of that study Trojano, Chiacchio, De Luca and Grossi (1994) found that patients did not benefit from longer presentation time nor from pointing to the correct stimulus from a four choice display. Kaskie and Storandt (1995) have found deficits on the Visual Form Discrimination Test, a task that minimises episodic memory demands. A longitudinal community study found that a decrease in immediate visual pattern memory prior to onset predicted later development of SDAT (Zonderman et al, 1995), while Small et al (1995) found that parietal asymmetry and baseline visuospatial memory scores were the best predictors of later development of SDAT. Impairment with the span tasks are consistent with an impairment of the VSSP, but it may also reflect difficulty at the level of the CES.

Some controversy exists as to whether visuospatial deficits in SDAT patients result from encoding difficulties or excessive decay due to faulty maintenance rehearsal mechanisms; the mixed findings may be related to the nature of the task. Money, Kirk and McNaughton (1992), using a computerised delayed matching to sample task which involved discriminating which of two circles was the same size as an initial sample, found that Alzheimer's patients showed poorer discriminability than controls at 0 seconds delay but showed similar rates of decay over time. Kopelman (1991), using Corsi Blocks and finger tapping as a distraction in the delay, also proposed that SDAT patients' short term memory impairment resulted from diminished processing resources and/or an encoding or retrieval deficit rather than an accelerated decay of the memory trace. By contrast, Sahakian et al (1988) found that Alzheimer's patients exhibited a delay-dependent deficit (over 0-16 seconds) in a delayed matching-to-sample procedure with complex irregular paterns, but were not impaired at a simultaneous matching-to-sample task. Corkin (1982), using Corsi Blocks, also found a more rapid rate of forgetting in SDAT patients than age matched controls. The deficits displayed do not indicate whether the VSSP per se is impaired or if a CES impairment contributes as well because many visuospatial short-term memory tests also utilise the resources of the CES (Baddeley et al, 1986).

Central Executive and attention in SDAT

In the context of attention in general, studies by Nebes & Brady (1989), Cossa et al (1989) and Freed et al (1989) showed no impairment in selective attention (visual search) in SDAT patients, but both voluntary and involuntary shifting of attention is impaired in SDAT (Greenwood, 1993; Parasuraman et al, 1992). Slowing on divided attention tasks is greater than expected on the basis of general cognitive slowing, and sustained attention is impaired at the highest level of task demands (Parasuraman & Haxby, 1993). Compared to normal elderly controls, SDAT patients show a disproportionate slowing in reaction time experiments (Nebes & Brady, 1992), especially once a decisional component is added (Gordon & Carson, 1990), and this impairment correlates with reduced brain metabolism in right premotor and right parietal association areas (Nestor et al, 1991).

The variety of attentional deficits that exist in early SDAT are consistent with the viewpoint that deficits occur at the level of the CES. In an extensive study using the Brown-Peterson task, Morris (1986) hypothesised that poorer short term memory recall in the SDAT patient group was due to a deficit in availability of central processing resources for maintenance rehearsal. Normal subjects are able to retain a consonant trigram over 20-30 seconds even though articulatory rehearsal is suppressed, but an interpolated backwards counting task causes rapid forgetting, suggesting that maintenance rehearsal in the absence of the articulatory loop requires CES resources. Morris (1986) showed that SDAT patients are able to maintain a consonant trigram during an unfilled delay, but show rapid forgetting when articulatory suppression is required during the delay. Wilson et al (1983) suggested that short term memory deficits reflect an inability to attend to incoming information, while Wright et al (1994) concluded that an impairment in the allocation of attention that specifically affects divided attention appears early in Alzheimer's disease.

Executive functions are used in most STM tasks requiring simultaneous processing and storage of information. The most substantial deficits in SDAT are exhibited in STM tasks requiring any form of divided attention, supporting the notion that the CES is impaired in SDAT. Lafleche and Albert (1995) found significant deficits in any task requiring concurrent manipulation of information. A longitudinal study by Baddeley et al (1991a) found a clear tendency for dual task performance (digit span combined with visuospatial tracking) to deteriorate over time while single task performance was maintained, independent of task difficulty, indicating an impairment of the integrating and coordinating function of the Central Executive in Working Memory (Morris & Baddeley, 1988). Performance on each component task was 'titrated' individually for each subject to emphasise the co-ordinating aspects of the dual task. Della Sala, Baddeley et al (1996) have recently replicated these findings. Other work has found that a group of (unspecified) dementia patients showed an impairment in a digit recall/ letter similarity dual task, even though they were not required to recall serial order information (Grober & Sliwinski, 1991). Morris (1986) concluded that the CES in SDAT is so limited that even simple distractor tasks which cause no forgetting in normal control subjects can cause interference in SDAT patients. By contrast, the age related effects on dual task performance found in the normal elderly, are greatly reduced when single task performance is taken into account (Salthouse et al, 1995).

THE CURRENT STUDY

The purpose of this study was to examine the acquisition and retention of visual patterns in Alzheimer's patients and in age-matched controls, the effects of various distractor ("interference") conditions during the delay period prior to recall, and the effect of increasing delay interval. The study involved the use of a forced choice recognition procedure as a visual analogue of the Brown-Peterson task, to study the VSSP and the CES from the perspective of maintenance rehearsal while ascertaining the effect of various distractors that place differential demands on the different components of working memory. SDAT subjects were expected to have poorer delayed recall and be more disproportionately affected by certain distractors than the control subjects, to provide further indication that the maintenance rehearsal processes of the CES in particular are impaired in SDAT.

The different distractor conditions were employed to differentiate the contributions of the various components of Working Memory in the memorising of visual information. Research with SDAT patients has found an overall decrement in both verbal and visual memory span, minimal impairment of the phonological loop, possible impairment of the VSSP and marked impairment of the CES. We expected to find a decrement in performance with increased delay intervals by the SDAT patients relative to the controls when there is no distractor (Sahakian et al, 1988) or the articulatory distractor (Morris, 1986). A verbal distractor would not be expected to disrupt the VSSP, therefore any disruption would indicate poor CES control. Most importantly, we predicted a more substantial level of impairment relative to the controls in an explicit CES distractor condition (Baddeley, 1991).

A decrement was also expected in recognition performance in the SDAT patients in both the simultaneous and 0 second delay conditions with increasing complexity of the stimuli. With particular reference to the VSSP, visual distractor during the delay interval would be expected to indicate an operative VSSP by a disruption of performance in the controls, if it interfered with visual retention; thus a lack of any such effect in SDAT patients relative to controls would be indicative of a specific VSSP effect.

In summary, this experimental study should indicate the relative levels of impairment in the VSSP and, in particular, the CES in SDAT patients.

CHAPTER TWO

METHOD

SUBJECTS

Two groups of subjects participated in this study. The SDAT group consisted of 8 older adults, 3 men and 5 women, who were recruited from nursing homes on the recommendation of staff, and from the Alzheimer Society and Presbyterian Support by asking for volunteers. General background information and diagnoses were made using established criteria, with the assistance of the non-physicians version of the screening protocol provided by the Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Three patients resided in nursing homes, three with their spouse in their own homes, one with her daughter and one in a granny flat attached to her son's home. All SDAT subjects were assessed as either mild (CDR 1) or questionable (CDR 0.5). Particular care was taken to exclude anyone suffering from depression and those who had evidence or history of alcohol abuse, stroke, central nervous system disorder, thyroid dysfunction or myocardial infarct. Several additional subjects participated in the experiment part of the study but had to be excluded because of previous serious head injury (one), long term insulin dependent diabetes (two), thyroid deficiency (one), signs of multi infarct dementia (one) and previous heart attacks (two).

The control group consisted of 8 older adults, 4 men and 4 women who were recruited from a retirement village and the community. The same medical exclusion criteria applied as with the patient group. Well controlled or mild hypertension was considered acceptable in either group as recent evidence suggests that mild hypertension alone has little effect on cognitive function (Grossman & Zalewski,1995).

There were no significant differences between the mean age, education, NART scores or estimated IQ of the two groups (see Table 2.1). One SDAT subject scored only 12 on the NART; without her score the mean SDAT NART score was 39.28 (sd. 13.2), and the mean estimated premorbid IQ rose to 117.3 (sd. 16.1).

All participants gave their written consent and consent was also obtained from the principal caregiver of the SDAT subjects. The project was conducted with the prior approval of the University of Canterbury Human Ethics Committee.

Table 2.1: Demographic variables of SDAT and control groups.

Demographic variables	SDAT (N=8)	Controls (N=8)
Gender		
Male	3	4
Female	5	4
Age (Yrs)		
Mean (SD)	76.9 (8.8)	73.25 (7)
Range	63-90	60-82
Education (Yrs)		
Mean(SD)	11.4 (2.6)	10.9 (4.2)
Range	8-16	7-20
NART		
Mean(SD)	37 (13.9)	39.9 (5.2)
Range	12-49	34-49
Estimated premorbid		
IQ	114.5 (16.88)	118.125 (6.33)
Mean(SD)	84-129	111-129
Range		

ASSESSMENT

The standardised neuropsychological test battery from the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) was administered to all participants. CERAD criteria were designed to exclude neurologic, medical and psychiatric disorders other than SDAT that could impair cognitive function, while gradual onset and progression of memory loss of at least 12 months duration are specified inclusionary features (Morris et al, 1989). The various subtest of the battery are summarized below in the order of administration.

Clinical Dementia Rating (CDR)

The clinical Dementia Rating is derived from a semistructured interview with the patient and an informant, and rates impairment in each of six categories (memory, orientation, judgement and personal problem solving, community affairs, home and hobbies, and personal care) on a five point scale in which 0 = none, 0.5 = questionable, 1 = mild, 2 = moderate and 3 = severe. Using established scoring rules, a global CDR is assigned using the same categories (Morris, 1993).

Short Blessed Test

The Short Blessed Test (Katzman, Brown, Fuld et al, 1983) rates the subject's orientation, memory and concentration. A total weighted score of 0 indicates no impairment while a score of 28 indicates maximum impairment.

Calculation, Clock and Language

The Calculation, Clock and Language test assesses simple mental calculation, the ability to produce a drawing of a clock correctly showing a specified time and the amount and quality of general speech. No impairment scores 0, maximal impairment scores 13.

Verbal Fluency

Verbal Fluency measures impairment in verbal production, semantic memory and language by recording the number of animals the subject could name in one minute.

Modified Boston Naming Test

The subject named 15 line drawings divided into low, medium and high frequency objects.

Mini-Mental State Examination

The Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975) is a brief cognitive assessment which measures orientation, memory, concentration, praxis and language. The maximum score is 30. Traditionally the cut off score that indicated impairment was <24 but more recent evidence suggests that <26 may indicate cognitive decline, especially when used in conjunction with other psychometric tests (Monsch et al, 1995).

Word List Memory

Subjects read 10 common nouns printed on cards at the rate of 1 every 2 seconds then try to recall as many as possible in any order immediately following presentation. The same 10 word are used in different orders on two subsequent trials with the number correctly recalled after each trial recorded.

Constructional Praxis

Subjects copied four simple geometric figures; a circle, diamond, overlapping rectangles and a cube, and were scored by specific criteria for their accuracy. The maximum score was 11.

Word List Recall

Subjects had 90 seconds to recall the 10 words presented in the Word List Memory task completed approximately 5 minutes earlier.

Word List Recognition

Subjects were shown the previous ten words interspersed by ten distractor words. They were required to indicate whether each word was from the previous list by "yes" or not by "no". To adjust for chance each subjects score is calculated as total number of correct answers minus 10.

Constructional Praxis Recall

Subjects were required to remember and draw the four figures they had copied in the previous constructional praxis task and if possible the intersecting pentagons from the MMSE. Maximum score was 14.

Trail Making Test A

The Trail Making Test requires simple motor/spatial skills (tracking) and basic sequencing abilities. The subject joins twentyfive numbered circles as quickly as possible. Time taken and number of errors are recorded.

Trail Making Test B

Subjects again join 25 circles but this time alternate numbers and letters in sequential order (ie., 1-A-2-B-3-C etc). This is a sensitive test of the additional attentional and cognitive flexibility required to shift between these two well learned sequences. Only 2 of the 8 SDAT subjects finished within the maximum time allowance of 5 minutes. Number of circles completed, time taken and number of errors were all recorded.

Additional Test

National Adult Reading Test (NART)

The NART requires the pronunciation of a list of 50 words which have an irregular spelling-to-sound correspondence (eg., ache). This well standardised test has been used to estimate the pre-morbid intelligence of SDAT patients, although recent research challenges this assumption (Storandt et al, 1995) as significant deficits in performance on the NART were observed in both very mild and mild SDAT patients.

Pre-morbid IQ was estimated by transforming NART scores using established norms which have been standardised against the WAIS-R (Nelson & Willison, 1991).

EXPERIMENTAL PROCEDURE

The study was conducted in the participant's home on a Macintosh Plus computer using stimuli generated with Hypercard. The visuospatial tasks involved computer presentation of patterns of stimuli. The subject performed a simultaneous discrimination task (Part 1), a matching-to-sample task with "zero". delay (immediate recall; Part 2), and the delayed matching-to-sample task with various distractor conditions in the delay interval (Part 3). The experiment was spread over three sessions of approximately 1- 1.5 hours (including rest breaks). The first experimental session was spent familiarising the participant with the computer equipment and the stimuli used, then, after some practice trials, part 1 and part 2 of the experiment were completed. Part 3 was then divided between the following two sessions, with each participant completing one block of each experimental condition during each session. The CERAD assessment package was administered during a separate session.

The stimulus pattern was a 5cm circle containing 12 randomly scattered "bugs", of which 3, 4, or 5 were black; the remaining bugs were uncoloured (see fig. 1 in the appendix). The location of the black bugs within the circle varied on each trial. Varying the number of black "bugs" allowed the use of potentially different "difficulty levels" to vary the complexity of the task. The subjects were seated in front of a computer monitor with their preferred hand resting comfortably on a response box with two raised buttons labelled "choice 1" and "choice 2", which corresponded to two "choice buttons" adjacent to two comparison stimuli on the computer screen. A third sample stimulus circle was provided above "choice 1" and "choice 2" and was present for the duration of the trial in Part 1 but preceded the comparison circles for Parts 2 and 3. On a random, balanced basis, either "choice 1" or "choice 2" was identical to the sample stimulus in terms of the overall number of "bugs" and the number and distribution of the black (filled) bugs. The subjects task was to identify which comparison stimulus was the same as the sample stimulus (a matching task). For any given experimental condition, there were 20 trials, tested over two separate blocks of 10 trials each. Breaking the experiment up into these short blocks ensured that the subjects did not lose their concentration or become fatigued. A break was available between each block with regular longer breaks throughout each session. Generally Part 1 and Part 2 each took less than a minute per block of trials; Part 3 took 2-5 mins per block.

Part 1 - simultaneous discrimination: three circles were present at the same time and these circles remained on the screen until a response choice was made. All three levels of difficulty (3, 4,and 5 black bugs) were tested, with 10 trials of one level in each block. As other studies have shown that people with early Alzheimer type dementia may have attentional/perceptual deficits as well as memory deficits (Grewal 1989), this task ensured that the subjects could actually discriminate between the different patterns and could understand what was required of them, while familiarising them with the stimuli and the equipment.

Part 2 - Matching-to-sample, with zero delay: The sample stimulus (3 black bugs) was presented for 3, 2 or 1 seconds and then removed, followed immediately by the two comparison circles (0 seconds delay). Each subject was then tested with 5 bug stimuli on 0 second delay with 3 second display. This part of the experiment tested encoding of the stimulus, with minimal time for decay, and provided a baseline measure for the longer delays introduced later. As each pattern was tested immediately after presentation this minimised the effects of interference by previous stimuli. At the same time the effects of the different difficulty levels could be ascertained.

The display time for each individual was then determined, on the basis of their performance in this section, to ensure comparable performance accuracy across all individuals at 0 seconds delay for Part 3.

Part 3 - Matching-to-sample, with different distractor conditions during the delay period: The remainder of the experiment drew on Baddeley's model of working memory, using various interference conditions that would be expected to affect the different component systems. An articulatory suppression task to occupy the phonological loop, a moving visual display to occupy the visuospatial sketchpad, while a simple counting task was used to occupy the central executive. The order of presentation of the different conditions was counterbalanced over subjects using a Latin square design. Part 3 used only the "3 bugs" level of complexity at both 3 seconds and 12 seconds delay between the sample circle and the comparison circles. Thus each subject was tested in four distractor conditions:

1. No distraction (blank screen during delay): this condition showed any memory decay over time in the absence of explicit distraction. The subjects were able to rehearse (recycle) or use any strategies they developed. Such strategies were noted if recalled by the subject at the end of the experiment.
2. Visual distraction: a small stylised train moved randomly round the screen during the delay interval. This information was "unattended" in that the subject was instructed to watch the screen but not to follow the train. The subjects should have been able to use strategies and rehearse as the central executive should be relatively unaffected. The phonological loop should also be unaffected. This condition tested Logie et al's (1990) finding that unattended visual information disrupted visual memory.
3. Articulatory suppression: repetition of "the" at approximately the same rate of 2-3 per second during the delay interval (blank screen). A metronome was not used to regulate the rate of articulation to avoid any additional distraction. There was no visual distraction and the repetition was well learned and automatic, thus placing minimal demand on the central executive.
4. Central executive task: counting backwards singly from a randomly selected number during the delay interval (blank screen). This task is believed to have little or no visual input but does employ both the central executive and the phonological loop, both in keeping a running total and in verbalising the answers. This should isolate the visuospatial sketchpad during retention of the pattern. It is uncertain as to the degree each pattern of bugs can be elaborated by different strategies to aid memorisation, but by occupying the central executive these strategies should become more difficult and/or be reduced.

STATISTICAL ANALYSES.

Each subject's response latency was calculated as the mean of the 20 trials in each condition. Extreme response latencies (> 2 SD's) were deleted from each subject's mean. Group means were then calculated from the subject means. Statistical calculations were carried out using the Statistica for Windows (Statsoft, Microsoft Corporation) package. Comparisons of means were based on appropriate t-tests and repeated measures analyses of variance and covariance. All correlations were of the Pearson product-moment type.

CHAPTER THREE

RESULTS

CERAD Neuropsychological Tests results

Mean scores on the memory and non-memory measures for the SDAT patients and the controls are summarized in table 3.1. T-tests showed significant overall group differences in all of the subtests in the CERAD Neuropsychological Test Battery except for the constructional praxis, where both groups were near ceiling, and the Trail B / Trail A time to completion ratio. All the significant subtests also had large effect sizes (median 1.96, range 1.17 - 4.55) where >0.8 is considered a large effect size (Cohen, 1990). Comparisons of the present SDAT sample with data from large sample CERAD studies are given later (see Table 3.2).

In the two general cognitive assessment tests there were, as expected, clear differences in the mean scores in the MMSE (SDAT = 23 (5.04), Controls = 29.5 (1.07)) and Short Blessed Test (SDAT = 12.63 (7.19), controls = 2.38 (3.46)), where lower MMSE and higher Short Blessed scores indicate greater impairment. Conventionally MMSE scores below 24 have been classified as probable SDAT, but more recent evidence suggests that <26 may indicate cognitive decline, especially when used in conjunction with other psychometric tests (Monsch et al, 1995).

The SDAT subjects were impaired on nearly all other tests. The two non-memory tests with the largest effect size were Verbal fluency, which is often indicative of cognitive decline, and Trail Making B, an indicator of cognitive flexibility. Although the SDAT subjects were considerably slower on Trail A, the extra effort of changing between the numbers and the letters in Trail B revealed the particular difficulty that SDAT subjects have in divided attention tasks. The Calculation and Clock drawing test also indicated that all subjects were able to count backwards, which was necessary for the experimental part of the study, while some of the SDAT subjects showed characteristic deficits in their clock drawing ability.

Of particular interest are the word list saving scores (SDAT=39%, SD= 37.9 and controls= 81%, SD=16.5, (t=2.84, p<.05). Following Welsh et al's (1994) formula (delayed recall/Trial 3 x 100 = savings) the savings score for each subject was computed to reflect the relative amount of verbal information retained over the delay interval. Although the difference between the groups appears large, the effect size (1.44) is not as substantial as the immediate and delayed recall effect sizes (2.76, 2.26). Delayed praxis recall also had a large effect size (2.84) while the adjusted word list recognition scores effect size was lower (1.79), suggesting that explicit recall is more compromised in the SDAT group than recognition memory, relative to age matched controls.

Correlations made across the combined groups found a strong correlation between delayed recall and the adjusted word list recognition scores ($R = .69$, $t(1,14) = 3.58$, $p < .005$), and between word list recall and constructional praxis recall ($R = .76$, $t(1,14) = 4.31$, $p < .001$).

Group membership was significantly correlated with all measures except demographics, NART score, constructional praxis and Trail B/Trail A ratio. MMSE scores were significantly correlated with all measures except age, gender, education, recognition 'yes' and Trail B/Trail A ratio.

Table 3.1: Means and Ranges of Scores on CERAD Neuropsychological Tests for SDAT Subjects and Controls.

CERAD measures (Maximum possible score shown in brackets.)	**SDAT (N=8)**	**Controls (N=8)**	**t value**	**Effect Size**
Clinical Dementia Rating (3)				
Mean (SD)	0.75 (.26)	0		
Range	0.5-1	0		
Mini-Mental State (30)				
Mean (SD)	23 (5.04)	29.5 (1.07)	3.57***	1.78
Range	13-28	27-30		
Short Blessed Test (28)				
Mean (SD)	12.625 (7.19)	2.375 (3.46)	3.63***	1.82
Range	0-20	0-10		
Calculation & Clock				
Mean (SD)	2.875 (1.89)	.875 (1.13)	2.58*	1.28
Range	0-6	0-3		
Fluency				
Mean(SD)	11.5 (3.42)	19.75 (3.85)	4.53****	2.29
Range	8-18	15-25		
Naming (15)				
Mean(SD)	11.75 (3.06)	14.375 (.92)	2.32*	1.17
Range	7-15	13-15		
Word List Memory (10)				
Trial 1			3.92***	1.96
Mean (SD)	2.5 (1.2)	5.25 (1.58)		
Range	1-5	2-7		
Trial 2				
Mean (SD)	4 (.93)	7.125 (1.46)	5.12****	2.55
Range	3-5	5-9		
Trial 3				
Mean (SD)	5 (.93)	7.5 (1.07)	5.0****	2.49
Range	4-6	6-9		
Word List Total (30)				
Mean (SD)	11.5 (2.33)	19.875 (3.6)	5.52****	2.76
Range	9-16	14-25		

p = * <.05, ** <.01, *** <.005, **** <.001.

Continued overleaf...

Table 3.1 continued

CERAD measures (Maximum possible score shown in brackets.)	**SDAT**	**Controls**	**t value**	**Effect size**
Word List Delayed Recall (10)	2.125 (2.23)	6.125 (1.13)	4.53****	2.26
Mean (SD)	0-5	5-8		
Range				
Word List Saving Score				
Mean (SD)	39% (37.9)	81% (16.5)	2.84*	1.44
Range	0-83%	71-117%		
Word List Recognition				
"Yes"(10)				
Mean (SD)	7.75 (2.49)	9.75 (.46)	2.23*	
Range	3-10	9-10	(MW)	
"No" (10)				
Mean (SD)	8.625 (1.3)	10 (0)	2.99*	
Range	7-10	10	(MW)	
Word List Recognition Total(10)				
Mean (SD)	6.375 (2.62)	9.75 (.46)	3.59***	1.79
Range				
Constructional Praxis (11)				
Mean (SD)	10 (1.41)	10.75 (.46)	1.42	
Range	7-11	10-11		
Praxis Recall (14)				
Mean (SD)	1.625 (1.6)	9 (3.3)	5.7****	2.84
Range	0-4	2-11		
Trail Making A Time Taken (360s)				
Mean (SD)	109.25 (48.9)	45.375 (6.55)	3.66***	1.83
Range	58-183	34-54		
Trail Making B Time Taken (300s)				
Mean (SD)	278.75 (47.57)	107.25 (24.18)	9.09****	4.55
Range	165-300	73-138		
Trail Making B/A Ratio				
Mean (SD)	2.89 (1)	2.39 (.56)	1.25	
Range	1.64-4.11	1.76-3.2		

p = * <.05, ** <.01, *** <.005, **** <.001. (MW) = Mann Whitney U.

Comparisons of the CERAD scores of this sample with those of two recent large sample studies (Morris et al, 1989; Welsh et al, 1991, 1992) are summarised in table 3.2 and 3.3. With respect to the control data, the means and ranges of scores achieved by the controls were generally comparable with Morris and Welsh's' controls, even though the present sample was slightly older than the other two samples and had significantly fewer years of education. Therefore the group of controls in the present study are representative of normal older adults in their performance on these particular cognitive measures.

With respect to the SDAT data, the means and ranges of scores of the SDAT patients were generally comparable to Welsh et al's sample except for lower MMSE scores, but were slightly better on most test scores except naming than Morris et al's sample. Morris's mild SDAT sample's mean MMSE score was lower than the current sample, and they only studied SDAT patients with a CDR = 1.0, indicating that the level of impairment would be expected to be greater in Morris's sample. The Welsh et al sample is perhaps a more comparable group, despite the fact that the present study's SDAT group were significantly older and had fewer years of education. The pattern of impairment on the range of neuropsychological tests within the CERAD battery of the present study's sample is representative of that found in the literature. Thus the comparability of the SDAT and control groups in the present study to previous large sample studies is an indication that, despite a small sample, the differential diagnosis of each subject is accurate across a range of neuropsychological tests pertinent to SDAT.

Table 3.2: Comparison of Mean Scores of Control Subjects in Present Study with Other Studies on Selected CERAD Neuropsychological Measures.

CERAD measures (Maximum possible score shown in brackets.)	**Controls Present study (N = 8)**	**Controls Morris et al (1989)(N = 278)**	**Controls Welsh et al (1991)(1992) (N= 49)**
Age			
Mean (SD)	73.25 (6.98)	68.1 (7.7) *	71.1 (6.7)
Education, yrs			
Mean (SD)	10.875 (4.22)	14.2 (2.9) ***	14.0 (2.9) **
Short Blessed Test (28)			
Mean (SD)	2.375 (3.46)	1.3 (2.1)	-
Fluency			
Mean(SD)	19.75 (3.85)	18.0 (4.8)	17.2 (4.0) *
Naming (15)			
Mean(SD)	14.375 (.92)	14.6 (0.6)	14.6 (0.7)
Mini-Mental State (30)			
Mean (SD)	29.5 (1.07)	28.9 (1.3)	28.9 (1)
Word List Memory (10)			
Trial 1			
Mean (SD)	5.25 (1.58)	5.4 (1.6)	4.8 (1.4)
Trial 2			
Mean (SD)	7.125 (1.46)	7.4 (1.5)	7.0 (1.5)
Trial 3			
Mean (SD)	7.5 (1.07)	8.3 (1.3) *	7.9 (1.6)
Word List Delayed Recall (10)			
Mean (SD)	6.125 (1.13)	7.2 (1.8) *	6.8 (1.9)
Word List Saving Score			
Mean (SD)	81% (16.5)	-	85.6% (19.3)
Word List Recognition			
"Yes"(10)			
Mean (SD)	9.75 (.46)	-	9.7 (0.6)
"No" (10)			
Mean (SD)	10 (0)	-	9.7 (1.5)
Word List Recognition Total			
Mean (SD)	9.75 (.46)	9.6 (0.8)	-
Constructional Praxis (11)			
Mean (SD)	10.75(.46)	10.1 (1.2)	9.8 (1.5) *

p= * < .1, ** < .05, *** < .01; t-test comparisons

Table 3.3: Comparison of Mean Scores of SDAT Subjects in Present Study with Other Studies on Selected CERAD Neuropsychological Measures.

CERAD measures (Maximum possible score shown in brackets.)	**SDAT Present study (N= 8) CDR = 0.5-1.0**	**SDAT Mild Morris et al (1989) (N = 200) CDR=1.0**	**SDAT Mild Welsh et al (1991) (1992) (N=49) 'mild' MMSE >24**
Age			
Mean (SD)	76.875 (8.79)	71.5 (8.0) *	71.2 (5.6) **
Education, yrs			
Mean (SD)	11.375 (2.6)	12.9 (3.3)	13.8 (2.5) **
Short Blessed Test (28)			
Mean (SD)	12.625 (7.19)	15.4 (5.2)	-
Fluency			
Mean(SD)	11.5 (3.42)	8.8 (3.9) *	11.0 (3.9)
Naming (15)			
Mean(SD)	11.75 (3.06)	11.8 (2.7)	13.0 (2.2)
Mini-Mental State (30)			
Mean (SD)	23 (5.04)	20 (3.9) **	25 (1) **
Word List Memory (10)			
Trial 1			
Mean (SD)	2.5 (1.2)	1.7 (1.4)	2.8 (1.4)
Trial 2			
Mean (SD)	4 (.93)	3.0 (1.7)	4.2 (1.5)
Trial 3			
Mean (SD)	5 (.93)	3.2 (1.8)***	4.7 (1.8)
Word List Delayed Recall(10)			
Mean (SD)	2.125 (2.23)	0.9 (1.4)**	1.8 (1.8)
Word List Saving Score			
Mean (SD)	39% (37.9)	-	35.8% (30.9)
Word List Recognition			
"Yes"(10)			
Mean (SD)	7.75 (2.49)	-	8.2(2.4)
"No" (10)			
Mean (SD)	8.625 (1.3)	-	7.7 (2.7)
Word List Recognition Total			
Mean (SD)	6.375 (2.62)	4.8 (2.7)	-
Constructional Praxis (11)			
Mean (SD)	10 (1.41)	7.8 (2.3) ***	8.9 (2.0)

p = * <.1, ** < .05, *** < .01; t-test comparisons.

SHORT-TERM VISUOSPATIAL PATTERN MEMORY RESULTS

One of the SDAT subjects had exceptionally long response latencies on all measures, resulting in a very large variance for the SDAT group. Her response latencies were deleted from the data analysis (but not her number of correct responses).

PART 1

Simultaneous Discrimination.

This part of the experiment was to ensure that all the subjects were able to discriminate the differences between the choice stimuli while at the same time familiarising them with the equipment and the stimuli. It also enabled those who were unfamiliar with computers to become more relaxed and less apprehensive, while the good results they achieved encouraged them to continue.

Response Latency

The mean response latencies of the two groups are summarised in Table 3.4.

Table 3.4 Mean response latencies (in seconds) of SDAT subjects and controls in simultaneous discrimination with increasing pattern difficulty.

Level of difficulty	**SDAT subjects (N=7)** **Mean (SD)**	**Controls (N=8)** **Mean (SD)**
"3 bugs"	7.97 (5.0)	5.66 (2.6)
"4 bugs"	10.13 (3.7)	6.45 (2.5)
"5 bugs"	8.7 (2.0)	6.36 (2.5)

Based on a repeated measure 2 (group) x 3 (difficulty level) analysis of variance (ANOVA) there was no significant effect of increasing difficulty levels (3, 4 or 5 black bugs per circle) on response latencies ($F(2,26) = 1.9$, NS). However, there was a trend for SDAT patients to take longer to respond than controls at all levels of difficulty, an effect that was close to significance ($F(1,13) = 3.94$, $P = .069$).

Correct Responses

The mean correct response scores of the two groups are summarised below in table 3.5.

Table 3.5 Mean correct response scores of SDAT subjects and controls in simultaneous discrimination with increasing pattern difficulty.

Level of difficulty	SDAT subjects (N=8)		Controls (N=8)	
	Mean	**(SD)**	**Mean**	**(SD)**
"3 bugs"	9.5	(0.53)	9.5	(0.76)
"4 bugs"	8.375	(1.77)	9.625	(0.52)
"5 bugs"	8.5	(1.7)	9.5	(0.76)

Based on a repeated measure 2 (group) x 3 (difficulty level) analysis of variance (ANOVA) there was no significant effect of increasing difficulty levels on the number of correct responses ($F(2,28) = 1.15$, NS). Group membership almost reached significance ($F(1,14) = 4.45$, $P=.053$), but there was no group by difficulty interaction ($F(2,28) = 1.51$, NS). Controls remained almost at ceiling while SDAT subjects declined slightly at the 4 and 5 bug levels.

The '3 bugs' level was used during the more difficult delay and distractor conditions in part 3 of the experiment, as both groups were equivalent at this level during simultaneous discrimination.

PART 2

Matching -to-sample, with zero delay and changing display time

Response Latency

Each participant was tested in the same order of presentation in this section (descending display time [3, 2, and 1 second] on 3 bugs, then 5 bugs with 3 second display only). Two SDAT subjects did not complete all conditions as they found it too difficult at the shorter display times or with the more complex patterns, while two had to be extended to 4 seconds display time. The main purpose here was to ascertain what display time to use in Part 3. Both groups decreased their response latency as the display time decreased in the 3 bugs condition (SDAT = 5.8s, 4.52s, 3.87s, Controls = 3.2s, 3.13s, 2.54s), but this may also be attributable to initial practice effects as all subjects had the same order of conditions. A 2 (group) x 3 (display time) repeated measure analysis of variance (ANOVA) of the subjects who completed all three display levels revealed a significant display time effect ($F(2,24) = 5.66$, $p < .01$), but there was no group membership effect ($F(1,12) = 1.77$, NS) or group by display time interaction ($F(2,24) = 1.71$, NS).

Mean response latencies between the 3 bug and the 5 bug levels of difficulty increased only slightly in both groups (SDAT = 3.94 - 4.3, controls = 3.2 - 3.4) with no significant or near significant effects.

Correct Responses

Both groups' mean correct response scores showed little change as the display time decreased (score out of 10 across 3s, 2s and 1s; SDAT = 8.16, 7.83, 7.83, controls = 8.75, 8.63, 8.0). A 2 (group) x 3 (display time) repeated measures ANOVA of those subjects who completed all three display levels revealed no significant effects or interactions (F's < 1.1, df's 1,12 or 2,24, p's > .31).

Mean correct response scores between the 3 bug and the 5 bug levels of difficulty decreased slightly in both groups (SDAT = 8.16 - 8.0, controls = 8.75 - 8.13) but a repeated measures ANOVA of those subjects who completed both levels of difficulty revealed there were no significant effects (F's < .8, df's 1,12 or 2,24, p's > .39).

PART 3

Matching-to-sample, with different distractor conditions during the delay period

This section of the experiment used only the 3 black bug level of difficulty for all subjects. However each subject's display time depended on their performance in Part 2. The SDAT subjects had either 3 or 4 seconds display time while controls' display times were either 1, 2 or 3 seconds, to ensure relatively high to maximum performance at 0 seconds delay in all subjects. The 0 second delay condition was repeated in this section of the experiment using each subject's display time, both at the start of each session as a practice, and again at the end of each session, the second result being used for analyses.

Response Latency

The mean response latency scores for each group in each distractor level at each delay interval are summarised in table 3.6.

Table 3.6 Mean response latencies of SDAT subjects and controls in different distractor conditions and at different delay intervals.

Distractor condition and delay interval	SDAT subjects (n=7) Mean (SD)	Controls (n=8) Mean (SD)
0 Second delay	4.14 (1.75)	2.71 (0.71)
No distractor		
3 second delay	4.11 (0.87)	2.99 (0.8)
12 second delay	5.28 (2.02)	3.59 (1.22)
Visual distractor		
3 second delay	4.62 (1.37)	3.12 (0.88)
12 second delay	5.7 (2.18)	3.56 (1.14)
Auditory distractor		
3 second delay	4.91 (1.49)	3.22 (1.07)
12 second delay	5.82 (3.12)	3.61 (1.14)
CES distractor		
3 second delay	6.37 (3.37)	3.43 (1.27)
12 second delay	7.41 (2.93)	3.89 (1.06)

A t-test on mean response latencies of the two groups at 0 seconds showed an almost significant difference ($t(1,13) = 2.13$, $P = .053$) between the SDAT subjects and the controls. The subsequent analyses therefore included the 0 second response latency as a covariate.

A 2 (groups) x 4 (distractor condition) x 2 (delay interval) analysis of covariance (ANCOVA) with repeated measures on the distractor conditions and delay intervals data yielded a delay effect ($F(1,13) = 11.06$, $p<.01$), in that both groups responded more slowly as the delay interval increased. Neither the group, group by delay, distractor by delay nor the group by distractor by delay interaction effects were statistically significant (all F's < 2.17, df = 1,12, 1,13 or 3,39, p. > 0.17).

There was a significant distractor condition effect ($F(3,39) = 10.14$, $p<.001$), with overall response latencies taking longer when the different distractors were presented than when there was no distractor. However, a group by distractor interaction effect ($F(3,39) = 5.05$, $p<.005$) was also revealed. Simple main effects analysis demonstrated that this group by distractor interaction stemmed from the lengthening response latencies of the SDAT group across distractor conditions ($F(3,39) = 13.83$, $p<.001$) while there was no increase in response latencies across distractor conditions for the controls ($F(3,42) = 0.11$, NS). Pairwise comparisons of the SDAT group across distractors showed that response latencies in the CES condition were slower than all other (no, visual and auditory) distractor conditions (all p values <0.005) and that the visual compared with no distractor condition was also significant ($p < 0.01$).

Subsequent interaction analyses (as part of the ANCOVA) of the no distractor and CES distractor conditions across groups (SDAT vs controls) confirmed a group by distractor interaction ($F(1,13) = 6.78$, $p < .05$) effect across these conditions. There were also significant group by distraction interactions for response latencies between the auditory distractor and the CES distractor ($F(1,13) = 11.16$, $p<.01$) and the visual distractor and the CES distractor ($F(1,13) = 4.97$, $p<.05$) but not between no distractor and the auditory distractor ($F(1,13) = 1.42$, NS) or the visual distractor and the auditory distractor ($F(1,13) = .1$, NS), although no distractor and the visual distractor

(F(1,13) = 3.83, p = .072) approached significance for this sample size, thus the greatest distractor effects in the SDAT group occurred in the CES condition.

To ascertain the effects of delay as separate from any distractor effects, the two delay intervals when there was no distractor (3 and 12 seconds) were used with the 0 second delay as a baseline measure in a 2 (group) x 3 (0, 3, and 12 sec) repeated measures ANOVA. This ANOVA yielded significant group (F(1,13) = 5.45, p. < .05) and increasing delay (F(1,26) = 9.75, p. < .001) effects, but no interaction effect (F(1,26) = .65, NS). Thus delay per se did not differentially increase response time in the SDAT group by comparison with controls

Correct Responses

The mean correct responses scores for each group in each distractor level at each delay interval are summarised in table 3.7.

Table 3.7 Mean correct response scores of SDAT subjects and controls in different distractor conditions and at different delay intervals.

Distractor condition and delay interval	**SDAT subjects (n=8) Mean**	**(SD)**	**Controls (n=8) Mean**	**(SD)**
0 Second delay	17.25	(1.91)	19.125	(1.36)
No distractor				
3 second delay	15.5	(2.98)	18.125	(1.64)
12 second delay	14.625	(4.21)	18.375	(1.18)
Visual distractor				
3 second delay	15.875	(2.03)	17.625	(1.51)
12 second delay	13.0	(3.12)	17.5	(2.27)
Auditory distractor				
3 second delay	14.375	(2.88)	17.25	(1.28)
12 second delay	13.375	(4.41)	16.5	(1.41)
CES distractor				
3 second delay	12.125	(2.85)	15.75	(2.12)
12 second delay	11.0	(3.46)	17.0	(2.33)

A t-test on the mean correct responses at 0 seconds delay revealed a significant difference ($t(1,14) = 2.27$, $P < .05$) between the SDAT group (score out of 20; mean = 17.25 (sd 1.91)) and the control group (mean = 19.125 (sd 1.36)). Subsequent analyses therefore included 0 second correct responses as a covariate.

A 2 (groups) x 4 (distractor conditions) x 2 (delay intervals) analysis of covariance (ANCOVA), with repeated measures on the distractor conditions and delay intervals yielded a significant group effect ($F(1,13) = 6.58$, $p < .05$), whereby the SDAT group had lower correct response scores across all conditions even when taking into account their relatively poorer performance at 0 seconds delay. There was also a distractor condition effect ($F(3,42) = 13.0$, $p < .001$), in which both groups performed more poorly across the distractor conditions than with no distractor. The differential effects on the mean number of correct responses of the CES distractor and the auditory distractor were greater than no distractor for both groups, and the SDAT group were apparently affected most by the CES distractor while in this group the visual and auditory distractors were intermediate in their effects. However the group by distractor interaction effect did not reach significance ($F(3,42) = 1.8$, NS). By contrast, the group by delay interaction effect almost reached statistical significance ($F(1,14) = 4.05$, $p =.064$), as controls' correct response scores did not change markedly over lengthening delay intervals ($F(1,14) = .08$, NS) whereas those of the SDAT subjects' showed a stronger decline ($F(1,14) = 6.61$, $p < .05$). The delay, distractor by delay and group by distractor by delay interaction effects were all non-significant (all F's < 2.7, df's 1,14 or 3,39, $p > .12$).

To ascertain the effects of delay as separate from any distractor effects, the two delay intervals when there was no distractor (3 and 12 seconds) were used with the 0 second delay as a baseline measure in a 2 (groups) x 3 (0s, 3s, and 12s) repeated measures ANOVA. This ANOVA yielded significant group ($F(1,14) = 8.51$, $p. < .05$) and increasing delay ($F(1,28) =3.71$, $p. < .05$) effects, but no interaction effect ($F(1,28) = .96$, NS). Thus delay per se did not differentially affect correct response scores in the SDAT group by comparison with controls. A pairwise comparison of the different delay levels found a significant effect from 0 seconds to 3 seconds delay ($F(1,14) = 4.84$, $p < .05$)

and 0 seconds to 12 seconds delay ($F(1,14) = 7.84$, $p < .05$) but no effect from 3 seconds delay to 12 seconds delay ($F(1,14) = .15$, NS).

Correlational analyses

Strong correlations were observed for the response latencies between the two delay intervals in the no distractor condition (.88), and each of these and the 0 seconds delay (N=15; 3s vs 0s, .83, 12s vs 0s, .84). These indicate that each participant's relative response latencies were consistent between the three different delay intervals.

Moderate correlations were observed for the correct response scores between the two delay intervals in the no distractor condition (.63), and between each of these and the 0 seconds delay (0s vs 3s, .51, 0s vs 12s, .37). This indicates that each participant's correct response score was relatively consistent between each of the three delay intervals.

There were also moderate negative correlations between each subject's response latency and correct response score at each delay interval in the no distractor condition and 0 seconds delay (0s -.49, 3s -.66, 12s -.64). Moderate to strong correlations were also observed between the response latency and correct response score in each of the distractor conditions (visual distractor 3 sec delay -.56, 12 sec delay -.6, auditory distractor 3 sec delay -.49, 12 sec delay -.77, CES distractor 3 sec delay -.72, 12 sec delay -.45). These were negative correlations because the lower the correct response score the longer the subject's response latency, and indicates that each participant was reasonably consistent between the different conditions.

Correlations between all subject's MMSE and response latencies in the various conditions were moderately negatively correlated (N=15; -.49 to -.72), indicating that slower responding in all conditions was associated with cognitive decline. However, correlations between MMSE scores and correct response scores in the various conditions were much more varied (N=16; .18 to .79). Short Blessed Test scores and response latencies were strongly correlated (.53 to .65), while Short Blessed Test scores and correct response scores were moderately negatively correlated (-.31 to -.66), indicating that increased cognitive impairment was associated with slower responding and lower correct response scores.

However, overall correlations between age and response latencies in the various conditions were non-significant (-.21 to .19) as were age and correct response scores (-.42 to .21) across the various distractor conditions, indicating that increased age did not consistently impact on accuracy or response latency.

Strong negative correlations were observed across all subjects between verbal fluency scores and response latencies (-.57 to -.75). This association could be an indication of an underlying retrieval problem.

CHAPTER FOUR

DISCUSSION

The main focus of the present study was to examine the acquisition and retention of visual patterns in SDAT subjects and in age-matched controls. A forced choice recognition procedure was used as a visual analogue of the Brown-Peterson task to study the VSSP and the CES from the perspective of maintenance rehearsal, while ascertaining the effect of various distractors that place differential demands on the different components of working memory.

The CES, Working Memory and SDAT

Despite the widespread acceptance of the theory that the CES is differentially impaired in SDAT (Baddeley, 1990), there has been relatively little evidence directly addressing the function of the CES in this disorder. The most prominent studies are Morris's (1986) verbal Brown-Peterson task and Baddeley et al's (1986) concurrent digit span and tracking task. Both studies found a substantial impairment in their mild to moderate SDAT patients when remembering small amounts of information for short periods while their attention was divided by even a relatively undemanding distractor task (Morris, 1994b). The present study attempted to simplify the task for the SDAT subjects by using novel computer generated patterns of stimuli in a recognition procedure, rather than explicit recall, and requiring only one pattern at a time to be remembered, removing sequential order at presentation or retrieval as possible confounding variables. While other studies have looked at the effects of delays on visual pattern memory (Sahakian et al , 1988, Money et al, 1992, Sahgal et al, 1991), the issue of the effects of different distractors during maintenance rehearsal of single visual patterns in SDAT subjects appears to have received little attention.

The most interesting finding in the present study was the differential effect of the different distractor conditions on the response latencies of the (very mild to mild, CDR 0.5 - 1.0) SDAT group relative to controls. The SDAT group clearly responded more slowly in the distractor conditions, particularly after the CES distractor, irrespective of the delay interval, whereas there was no increase in response time across distractors in the control group. Baddeley's (1986) proposition that the CES is differentially impaired in SDAT would predict that any activity which is concurrent to maintenance rehearsal would cause a decrement in performance, as one of the tasks of the CES is assumed to be an attentional controller that co-ordinates and schedules the performance of two concurrent tasks. In the present study, the introduction of distractors resulted in an increase in response latency, indicating that the SDAT subjects were impaired relative to controls in concurrent maintenance rehearsal of the visual pattern and performance of the distractor task. Even though the SDAT subjects all completed the backwards counting task without errors, indicating that it was well within their capabilities, the CES distractor caused differential slowing of response latencies for the delayed matching to sample task in the SDAT group, while their correct response scores were close to chance levels (12.1 & 11). The control group did not show changes in their response times but did show a small decline in correct responses in the CES distractor condition relative to no distractor, indicating that the CES distractor may be capable of affecting the maintenance rehearsal of a visual pattern even in controls. From the theoretical context of Baddeley's working memory model, the auditory and visual distraction would be expected to have less effect on the CES than counting backwards, as they would be expected to make fewer demands on the CES.

As expected the results of this study showed a clear difference between the SDAT group and the controls in mean correct response scores. The controls performed better than the SDAT group across the various delayed conditions, even when the scores at 0 second delay were taken into account. There was no clear indication, however, that the different distractors differentially affected this measure in the SDAT subjects. This negative result was probably due to a lack of power caused by too few subjects, and by measurement problems. By only having two patterns to choose from, the range of correct response scores before reaching chance level was narrow, leaving little room for measurable decline. When the data set was doubled in a replication analysis (to simulate an increase in sample size to improve statistical power), many of the other effects and interactions became highly significant, particularly the group effect on response latencies ($F(1,27) = 4.89$, $p < .05$) and the important group by distractor interaction on correct response scores ($F(3,84) = 5.03$, $p < .005$). This indicates that with a larger sample size, the correct score measure would probably also show a differential effect of distractor conditions on correct response scores, evidence consistent with CES impairment in SDAT.

Nevertheless, for correct response scores, there was a group by delay interaction effect. Even though the SDAT group performed more poorly at 0 seconds delay in the present study, the effect was exacerbated by the introduction of delay intervals, as the controls' correct response scores did not change markedly over the different delay intervals while the SDAT subjects' decreased with lengthening delay. This is also consistent with an impairment in the CES, in that increasing delays would be expected to make greater demands on maintenance rehearsal especially with concurrent distractors.

Indications of a slight decrement in performance with the auditory distractor as well as the CES distractor may indicate that self generated distraction, rather than passively watching the visual distractor, disrupts memory for visual patterns. Rather than indicating an interaction of the VSSP with the phonological loop, the auditory distraction effect could be more easily explained by the requirement to shift attention from generating and verbalising the auditory response to attending to the two choice stimuli on the screen, comparing them to the representation in the VSSP and responding correctly, indicating the cost to the CES of active dual task performance. If any of the subjects had managed to verbally recode any of the patterns, rehearsal of this would have been disrupted by the auditory distraction task, ensuring that only the visual memory was being tested.

The present study is another example of the dual-task paradigm that has been used to demonstrate the effects of divided attention on different aspects of working memory in SDAT. One landmark study by Baddeley et al (1986) used pursuit tracking, adjusted to equate performance at baseline, combined with simple counting, tone detection and digit recall also adjusted to each subject's span. Concurrent articulation, which had no effect on controls, caused a slight decrease in tracking accuracy in mild SDAT patients, while digit recall produced a substantially larger deficit in both tasks, even though the tasks had been titrated for each subject individually. Thus the co-ordination of concurrent activities by the CES is impaired such that even a relatively undemanding distractor task which makes small demands on the CES is disruptive in SDAT. In the current study the visual and auditory distractors, which had no detrimental effect on maintenance rehearsal in the controls, resulted in increased response latencies in the SDAT subjects.

Another divided attention task is the Brown-Peterson task, commonly used to assess short-term forgetting. It involves memorising small quantities (usually word or consonant triads) of verbal material (presented either visually or orally) over varying delays of 0 to 30 seconds, during which time a distractor task (such as counting backwards) is performed to prevent rehearsal (Peterson & Peterson 1959). Morris (1986), using the Brown-Peterson task, found that normal subjects were able to perform simple tasks such as tapping or articulatory suppression with no effect on trigram memory. However, although SDAT patients showed no impairment when there was no distractor in the delay interval, even these simple secondary activities caused an impairment in performance, with the greatest impairment caused by CES distraction. Morris and Baddeley (1988), when discussing the verbal Brown-Peterson task, suggested that the more demanding the distractor activity, the greater the demands on the CES, the more difficult it is to maintain rehearsal, therefore the greater the rate of forgetting. Similarly in the present study, the CES distractor caused near chance accuracy and the slowest response latencies in the SDAT group.

Non-verbal analogues of the Brown-Peterson task, using Corsi block sequences titrated to the individual's block span, also found deficits in SDAT patients across all conditions (Sullivan, Corkin & Growden1986), even when correct order was not required at recall (Kopelman 1992). However this method still required sequential ordering at acquisition so the current study differs in the removal of order effects at both acquisition and retrieval by presenting single patterns for immediate and delayed recognition. The use of the forced choice delayed matching to sample procedure was designed to minimise some of the problems that SDAT subjects have with explicit recall by using only recognition at all stages of the experiment.

Another aspect of CES function is in the selection of strategies during different cognitive operations, including encoding and retrieval. This is indicated in the performance on immediate (0 second delay) matching to sample in Part 3 of this study by the SDAT group, who were poorer than controls in both response latency and mean correct response scores, despite varying the display time for each subject to attempt to equate their performance. Other research has shown that SDAT subjects can focus on relevant information as effectively as normal individuals (Nebes & Brady, 1989), and those with mild SDAT perform as well as normal elderly control subjects on auditory and visual vigilance tasks (Lines et al, 1991), indicating that attention and orientation to the stimulus at acquisition is not impaired in SDAT. Grossi et al (1993) developed a variant of the Corsi Block Test that removed the requirement for correct order at acquisition and recall, but found that SDAT patients still had a lower block span than controls on immediate recall. Therefore, as the SDAT subjects in the present study had demonstrated in the simultaneous discrimination condition that they could successfully discriminate the patterns, the problems at 0 second delay may have stemmed from encoding and initial storage deficits, which may involve strategy selection problems, rather than insufficient encoding time, as Baddeley, Bressi et al (1991a) have suggested that SDAT patients have an impairment in the ability to choose strategies and allocate attention at encoding.

The individual strategies chosen by each participant in the present study were varied. Two controls and one SDAT subject used a mental representation of a clock face to try and remember the position of the black bugs, which may have involved some verbal recoding of the stimulus, but most of the participants tried to remember lines or angles between the black bugs or other relational aspects, a far more spatial type of memory trace. There appeared to be no difference in strategies between the two groups, but the efficiency with which they used their strategy is unknown.

Indications of deficits in dual task experiments or where cognitive flexibility is required may be reflected here in the requirement to rapidly switch from encoding to retrieval. During the 3 second no distractor condition, some of the SDAT subjects commented that they found it easier to remember the pattern after they had time to "organise" it in their memory than when required to make an immediate choice.

Working Memory theorists have recently argued against the concept of a 'unitary holistic executive' in favour of a fractionation of the CES into subcomponents (Della Sala, Baddeley et al, 1996). Although originally little more than 'a ragbag into which would be stuffed all the complex strategy selection, planning, and retrieval checking' involved with even a simple digit span task (Baddeley, 1996), attempts to specify and analyse the component functions of the CES have led to differing research directions: co-ordination of concurrent tasks, switching of retrieval strategies, selective attention to one stimulus while inhibiting the disruptive effect of others and holding and manipulating information in long-term memory. These areas have been investigated in SDAT, with concurrent dual task performance a frequently used method because of the greater demand these tasks place on the ability to sequence and co-ordinate mental activity . However maintenance rehearsal may perhaps use different component functions of the CES than co-ordinating a concurrent tracking / digit span divided attention task, so the generalisability of studies to all aspects of the CES is less certain.

Many of the well documented neurobiological markers of SDAT are concentrated in areas which are being identified with CES functions (Morris, 1994a). However, Baddeley's proposition that a deficit in the central executive component of working memory is characteristic of SDAT from an early stage, particularly in the integration of the performance of two or more concurrent tasks, has been challenged by other theorists.

Alternative explanations

One Alternative (but complementary) theory suggests that one of the first signs of SDAT is an increasing failure to initiate quickly and allocate properly the attentional resources needed to support a particular cognitive activity about to start or already occurring (Spinnler, 1991). Thus SDAT could be seen as mainly a deficit in attentional control, without recourse to any CES notion, in that impaired performance in SDAT reflects the increased attentional demands of more complex tasks (Parasuraman & Haxby, 1993).

Norman and Shallice's supervisory attentional system (SAS), on which Baddeley based his CES in the working memory model, has been used as a theoretical framework in which contention scheduling procedures operate schemata, which are routine programmes for the control of overlearned skills. The SAS acts to handle non-routine behaviours, and has recently also been fractionated into several component processes (Stuss, Shallice et al, 1996). Five of these component processes which are considered particularly important in attention are: energization of schemata, inhibition of schemata, adjustment of contention scheduling, monitoring of schema activity and control of the 'if-then' logical processes. Various component processes have been defined and characterized in tasks which are considered to control attention: sustaining, concentrating, sharing, suppressing, switching, preparing and setting. Deficits in SDAT occur as attentional resources decline and normally automatic schemata are progressively transformed into controlled actions and environment-driven stimuli and actions can no longer be inhibited. This model, however, has difficulty accounting for evidence suggesting separable modular sub-systems (Baddeley, Bressi et al, 1991), in that a verbal task can impair other verbal tasks but have no effect on visuo-spatial tasks in normal people.

Another theory, that SDAT represents extreme age-related cognitive slowing, is also not supported by the modularity of the deficits seen in SDAT. Salthouse et al (1995) found that previously reported age related effects of dual-task performance in the elderly generally disappeared when single task performance was taken into account. Slower processing speed, rather than decreased efficiency in the CES, appear to be involved in the effects of age on the performance of two concurrent tasks in the normal elderly. Although learning or acquisition of information declines with age, delayed recall or forgetting rates remain stable across normal aging when adjusted for the amount initially learned (Peterson et al, 1992). Slower processing speed with aging influences encoding time rather than the rate that information decays or is displaced over time (Salthouse, 1994). This is evident in the present study in that although some of the older controls (80+) needed a longer display time than the younger elderly controls, their correct response scores were comparable, therefore they took longer to encode the stimuli but their maintenance rehearsal was intact. A moderate correlation of age with response latency (.4 to .7) amongst the controls indicated general motor response slowing, whereas a similar correlation between age and response latency amongst the SDAT group showed variable negative correlations (-.22 to -.75), indicating that the younger SDAT subjects were actually responding slower, therefore age was not as strong an influence as cognitive decline on response latency amongst the SDAT subjects. The differential impairment of SDAT subjects in dual task conditions reflects a different pattern of deficits to normal aging, with deficits in the capacity to direct and control attentional resources indicative of an abnormal cognitive impairment that differs from accelerated aging.

Visuospatial performance in SDAT

As one of the problems in SDAT is spatial disorientation (wandering and getting lost), another area which has generated increasing attention in recent years is that of visuospatial performance in general. Recent studies indicate that some SDAT patients may have visuoperceptual (Grewal, 1989), visual processing (Ricker et al, 1994, Mendez et al, 1990) and/or complex visual field disturbances (Trick et al, 1995) which further compromise their ability to encode and store novel visual information. Kaskie and Storandt (1995) found a deficit of simultaneous matching to sample of more complex figures amongst even very mild (CDR 0.5) SDAT patients, indicating that SDAT patients can have deficits with more complex visual material, although the majority of the errors involved peripheral figures. However, all the participants in the current study successfully completed the simultaneous discrimination task to continue to the delayed task, thus it is unlikely that any of this SDAT group had any significant visual processing problems. The ability of all the participants to complete the simultaneous discrimination task indicated that they understood and could execute the requirements of the task and that their visual acuity and attention was sufficient to distinguish the target stimulus from the distractor. Thus subsequent deficits in the SDAT group were not the result of visual perception problems or failure to understand the basic requirements of the task. This replicates Trojano et al's (1994) finding that SDAT patients performed as well as controls on simultaneous matching to sample of simple block patterns, but were significantly impaired at immediate delayed matching to sample where four patterns were presented on a card, from which the subject only had to point to the correct stimulus.

One of the intentions of this study was to attempt to shed further light on the visuospatial sketchpad. Logie & Marchetti's (1991) postulated interference effect by a changing state visual distractor on the passive visual store would have predicted a slight deficit in visuospatial memory in the controls in the present study. However, controls were unaffected by the visual distractor in either response latency or correct response scores. By contrast the SDAT group were slower in their response latencies after the visual distractor than with no distractor, indicating that they were unable to completely ignore the visual distractor. However, their correct response scores in the visual distractor condition were not significantly different to the no distractor condition, indicating that, although the dividing of their attention caused slowing in response latencies, the present data did not reveal any specific VSSP impairment of pattern memory in this group. Thus, the obligatory access of the unattended visual material proposed by Logie and Marchetti (1991) was not evident in the current study. Hale et al (1996), however, recently found that active pointing or visually guided responding during maintenance rehearsal was necessary before spatial location information was disrupted. Therefore the passive watching of the visual distractor may not have been sufficient to disrupt visuospatial memory in the present study.

Delay or encoding deficits in SDAT?

Another area of debate in recent years has centred on whether SDAT patients exhibit increased rates of memory decay over time, or whether delay dependent deficits results from faulty encoding mechanisms. When looking at just the no distractor condition over different delay intervals, the present study found significant group and delay effects in both response latency and correct response scores, but no interaction effect; thus delay per se did not differentially impair the SDAT's response latencies when there was no distraction.

Several recent studies of the effect of increasing delay on forgetting rates of visual stimuli, when there was no distraction during the maintenance rehearsal period, have produced varying results. Money et al (1992) found that both SDAT patients and controls showed similar rates of decay once initial performance at 0 delay was accounted for. This they explained as resulting from a deficit in encoding, initial storage or retrieval mechanisms in SDAT. By contrast, Sahakian et al (1988) and Sahgal et al (1991) both found a delay-dependent deficit (over 0-16 secs) in delayed matching-to-sample in mild SDAT subjects, but no impairment in simultaneous matching-to-sample. Kopelman (1994) concluded that the difference in the slope of the forgetting curves between SDAT patients and controls is confined to the interval between immediate recall and the second datapoint (ie. 2 seconds in his 1992 experiment) with normal forgetting curves from there out to 30 seconds delay. Kopelman concluded that this result was evidence of an underlying encoding deficit or impairment in selection of retrieval strategy. The present study also found in the pairwise comparison of delay intervals that there was a significant decline in correct response scores in the SDAT group from 0 seconds to 3 second but not between 3 and 12 seconds delay, agreeing with Kopelman's conclusion.

Non-verbal analogues of the Brown-Peterson task, using Corsi block sequences titrated to the individual's block span with finger tapping as the distractor task, also found deficits in SDAT patients across all delay conditions, even when correct order was not required at recall (Kopelman, 1992). However this method still required sequential ordering at acquisition which may have impaired their encoding ability. As the present study tested each pattern immediately after presentation, and the subject only had to remember one pattern at a time, there may have been little interference from previous stimuli. Phillips and Christie (1977), using recognition of matrix patterns, reported a marked recency effect, in that the last matrix pattern presented was recognised correctly significantly more often by SDAT patients than earlier items in the sequence.

Problems with current experimental design

A number of methodological issues in the design of the present experiment need to be addressed. The choice of stimuli to be used in any visual memory study is difficult because of problems finding patterns which cannot be verbally recoded. Money et al (1992) used memory for the size of simple filled circles in their delayed matching to sample task, claiming that other more complex stimuli should not be used as they can be supported by verbal recoding. However holding in memory the exact size of a circle is difficult for even normal healthy adults, as although their controls scored at 90% correct at 0 delay, they showed a definite decrement in performance at 16 seconds delay, whereas Sahakian et al's (1988) controls showed no decrement in performance at 16 seconds delay when abstract visual patterns were used. Sahgal et al (1991), using similar abstract visual patterns in a computerised delayed matching to sample task with SDAT patients, found during their error analysis that most errors were the correct colour but the wrong shape, indicating that colour is a strongly coded variable. As a consequence, only black and white stimuli were used in the current study to minimise another potential confounding variable of colour, while ensuring that the patterns were clearly visible, enabling the focus to be on pattern recognition. All of the participants reported that they had no trouble seeing the stimuli.

Another contrast between Money et al's (1992) and Sahakian et al's (1988) experiments was in the order of presentation of the delay intervals. Sahakian et al used an ascending sequence of delays to avoid possible surprise effects, which they had found in pilot studies with SDAT patients when short delays followed long delays. However Money et al suggested that the predictability of the delay may lead to the adoption of specific delay-related strategies, so they used a quasi-random presentation of their 6 different delay intervals. In the present study, the constraints of the testing procedure was such that where only one delay interval of either 0, 3 or 12 seconds could be used in each block of ten trials, and permitted participants to use any strategies which they had developed, although most reported that they used the same strategy in all the different conditions. Therefore, there should have been no surprise effects, while the prior knowledge of the delay interval and the distractor condition should have enabled optimum performance by the participants if strategies were going to make much difference. To guard against any order effects between the different distractor conditions, the order of presentation of the different conditions (no, visual, auditory or CES distractor, for either 3 or 12 seconds) was counterbalanced over subjects using a Latin square design.

Some caution must be used when interpreting response time data as previous studies have found SDAT patients are proportionally slower on simple reaction time measures than normal elderly (Nebes & Brady, 1992), while they are disproportionally slower under certain experimental conditions, namely choice reaction time and divided attention conditions, suggesting that they have specific cognitive impairments not seen in the normal elderly. This slowing occurs in both the decisional and sensorimotor components of the choice process (Gordon & Carson, 1990). However response latency does give a more open ended measure of performance without the floor and ceiling problems of the correct response scores.

Although the SDAT subjects were impaired relative to the controls in the present study, they still performed better than chance on correct response scores. This is in contrast to Galloway et al (1992) whose SDAT patients viewed 12 patterns sequentially then chose each familiar pattern from a choice of 2. These subjects performed at or near chance, indicating that they were markedly impaired at remembering more than one pattern at a time. In the present study only one pattern at a time had to be remembered, but by only having two patterns to choose from, the range of correct response scores before reaching chance level was narrow, leaving little room for measurable decline. If more false alternatives were available on each trial, as used by Sahakian et al (1988) and Sahgal et al (1991), then there would be more opportunity to detect any decline in performance; however that may also increase the difficulty of the task beyond the ability of some SDAT subjects. It would also then necessitate the use of a touch screen computer as many of the SDAT subjects would find it too confusing when faced with more than two buttons with which to respond. The participants were also required to move their focus of attention from the top of the screen, where the sample stimulus was presented, to the bottom of the screen, where the two choice stimuli were presented, then make a motor response of pressing the correct button. Even with only two buttons, some more severe SDAT patients were unable to participate in the study as they were unable to transfer their pattern choice from the monitor screen to the response buttons. This particular study is therefore probably only suitable for use with very mild or mild SDAT subjects.

Diagnostic issues

As with any study of patients with probable SDAT, there is a potential problem with differential diagnosis. There is a possibility that one or more of the SDAT group may actually be suffering from a dementia of some other cause. However, other possible causes for dementia in the present study are improbable given the use of rigid inclusion/exclusion criteria, the extensive neuropsychological testing with a well verified test battery, and the comparability of these subjects with previously published large sample studies. In addition, several subjects with memory problems were excluded because of previous or existing medical conditions which have been associated with other causes of dementia.

The means and ranges of scores achieved by the controls were generally comparable with results of recent research using the CERAD battery (Morris et al, 1989, Welsh et al, 1991, 1992) even though this sample were slightly older than the other two samples and had significantly fewer years of education. One of the problems of using normative data from USA is the lower rate of education in New Zealand during the 1920's to 40's, in particular during the Depression, when many of the participants of this study were at school. Many spoke of being forced to leave school at 14 to help support the family, with only two subjects in each group having tertiary qualifications. Therefore years of education probably does not accurately reflect premorbid IQ in an elderly New Zealand population.

The means and ranges of scores of the SDAT patients were generally comparable to Welsh et al's sample except for lower MMSE scores (Welsh's criterion was MMSE >24), but were slightly better on most test scores, except naming, than Morris et al's sample. Morris's mild SDAT sample's mean MMSE score was lower than the current sample, and they only studied SDAT patients with a CDR = 1.0, indicating that the level of impairment would be expected to be greater in Morris's sample. Therefore the Welsh et al sample is perhaps a more comparable group. Thus the pattern of impairment on the range of neuropsychological tests within the CERAD battery of the present study's sample is representative of that found in the literature. The comparability of the two groups to previous large sample established dementia rating scores is an indication that, despite such a small sample, the differential diagnosis of each subject was accurate across a range of neuropsychological tests pertinent to SDAT.

The greatest effect sizes were observed in the verbal fluency, word list memory (both immediate and delayed recall), praxis recall and Trail making B. These findings are consistent with those of Welsh et al (1991) who found impairment of delayed recall to be the best discriminator for detecting mild cases of SDAT. Welsh et al's (1994) normative study found that delayed recall and savings scores were relatively unaffected by age, education or gender and that a decrease in savings score in particular may be useful in distinguishing between SDAT and normal aging (Troster et al, 1993), especially when considered in conjunction with delayed recall. Trail making B, which measures the focusing and shifting of visual attention, has been shown to be sensitive to the onset of mild SDAT, preceding deficits in other non-memory cognitive functions (Parasuraman et al, 1992), while larger than normal Trail B/ Trail A ratios have also been postulated as present early in the course of SDAT (Lamberty et al, 1994).

The SDAT subjects' mean Trail B / Trail A ratio (2.89) in the present study was distorted by the fact that the SDAT patients all managed to complete the Trail-A, although considerably slower than the control group, but 5 of the 8 SDAT patients were unable to complete Trail-B in the maximum allowable time of 5 minutes or made 5 errors, the criteria for terminating the test under the CERAD protocol. This meant our ratio was lower than Lamberty et al's (1994) SDAT sample (3.73) and nearer the mean ratio (2.38) of the normal elderly sample used by Ernst (1987). The age range (65-75) of Ernst's sample was slightly younger than this study (63-90 for SDAT, 60-82 for controls), but the controls' mean ratio (2.39) was almost the same as Ernst's sample (2.38). The mean TMT-A time (109.25) and TMT-B time (278.75) for the SDAT group was considerably slower than Lamberty's SDAT group (TMT-A= 61.9, TMT-B= 214.3) while the controls' mean TMT-A time (45.38) and TMT-B time (107.25) was comparable to Ernst's elderly sample (TMT-A= 41.5, TMT-B= 98.8). Therefore, although the controls were comparable in performance to a normal elderly sample, the SDAT group in the present study appeared unimpaired relative to Lamberty's SDAT group. While Lamberty asserts that a Trail B / Trail A ratio of 2.0 to 2.5 represents normative performance, and a ratio of 3.0 or greater indicates the presence of neuropsychological impairment, there were some amongst the oldest controls who were approaching this ratio. Thus some caution must be used when applying Lamberty's formula to Trailmaking scores. Some other scoring method may have to be devised under the CERAD protocol in order to assess this relationship.

The use of the NART to estimate premorbid IQ has recently been questioned. Storandt et al (1995) observed significant deficits in performance on the NART in both very mild and mild SDAT patients. Although the NART is resistant to the effects of aging to at least 80 years, longitudinal studies with SDAT patients have found that NART scores decline after 2 years and are significantly correlated with dementia rating (Morris & McKiernan, 1994). The deterioration has been attributed to the eventual decline of semantic memory and access to the lexicon (Nebes, 1989). In the present study NART scores did not differ between controls and SDAT subjects, while the SDAT males actually had higher rated occupations (2 managers and 1 school inspector) than some of the controls (engineer, freezing worker and mechanics).

Areas of future research

The current study produced some interesting results which would be clarified by further refinements. Despite the small sample of SDAT subjects, other published studies (Kopelman, 1992) have found significant results with only six subjects in the patient group. With further refinements, this experiment may be able to show more clearly the deficits in visuospatial memory of even a limited number of SDAT subjects. An extension with the present patient group with more subjects is warranted, however, with more time spent establishing a more accurate display time for each subject to better equate their performance at 0 seconds delay. A fuller investigation of each individual's span may also yield some interesting data. Changes to the visual distractor condition, such that the distractor must be followed either visually or physically (by pointing) could more accurately disrupt the VSSP, in line with Hale et al's (1996) finding that such tracking is needed to disrupt spatial memory in normal controls. As already mentioned, the use of a touch screen computer with more false choices in the recognition task would enable a wider range of possible scores between chance and maximal performance, ensuring that any decline is more measurable.

This study could also be used to investigate short term visual memory in other patient groups (eg., Huntington's, Parkinson's, Korsakoff's or multi-infarct dementia) and the effects of concurrent task performance on accuracy of recognition and response latencies.

Contributions of the present study

Although the sample size of the present study was not large enough to detect an interaction between group membership and the different distractors on correct response scores, there was a differential deficit in accuracy between the groups across delay intervals. Nonetheless there was a clear differential slowing of response latencies across distractors in the SDAT group relative to the controls. The present study, despite some limitations, has provided some valuable contributions to the current field of research on working memory. The findings add further evidence to Baddeley's proposition that the CES is differentially impaired in SDAT, in that any subsidiary task concurrent with maintenance rehearsal causes a decrement in performance.

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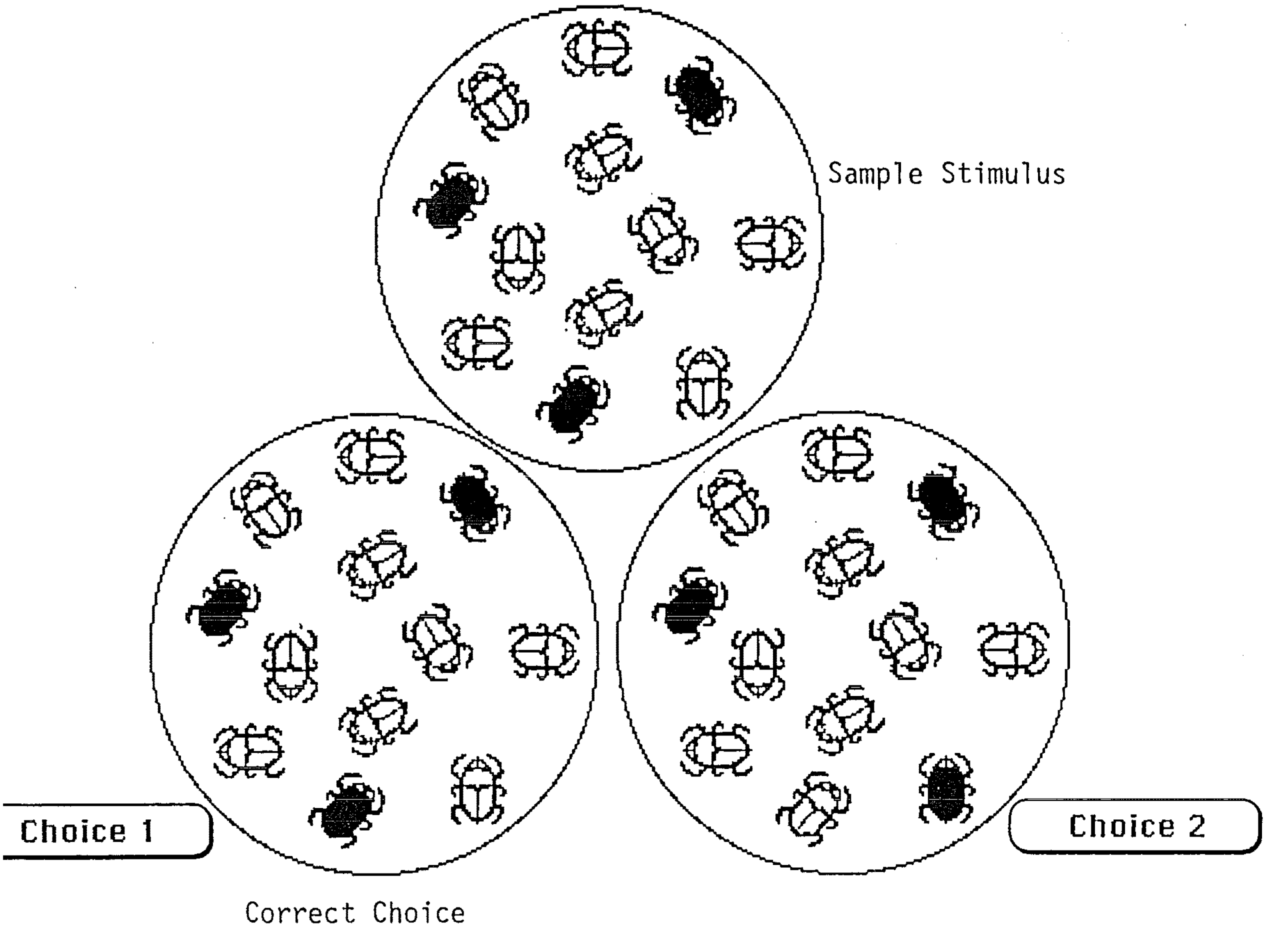

Fig 1: Sample stimulus pattern from simultaneous discrimination condition

Appendix 2.1: ANCOVA summary table response latencies.

STAT. GENERAL MANOVA — Summary of all Effects; design: (bugs5.sta) 1-GROUP, 2-DISTRACT, 3-DELAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Group	1	6.01593	12	2.767646	2.17366	.166137
Distractor	3*	9.28173*	39*	.914925*	10.14480*	.000045*
Delay	1*	17.31692*	13*	1.565868*	11.05899*	.005473*
Group X distractor	3*	4.61902*	39*	.914925*	5.04853*	.004736*
Group X delay	1	2.45603	13	1.565868	1.56848	.232490
Distractor X delay	3	.07236	39	.585290	.12364	.945593
Group X distractor X delay	3	.00562	39	.585290	.00960	.998688

Appendix 2.2: ANCOVA summary table correct response scores.

STAT. GENERAL MANOVA — Summary of all Effects; design: (bugs5.sta) 1-GROUP, 2-DISTRACT, 3-DELAY

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Group	1*	167.6278*	13*	25.46239*	6.58335*	.023480*
Distractor	3*	42.1042*	42*	3.23884*	12.99977*	.000004*
Delay	1	13.7813	14	5.22098	2.63959	.126523
Group X distractor	3	5.8854	42	3.23884	1.81714	.158718
Group X delay	1	21.1250	14	5.22098	4.04617	.063931
Distractor X delay	3	3.7188	42	4.49777	.82680	.486566
Group X distractor X delay	3	2.6458	42	4.49777	.58825	.626095

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INFORMATION FOR 'MEMORY IN THE ELDERLY STUDY.'

You are invited to participate as a subject in a research project on short term memory in the elderly.

We would like to study people who have been experiencing memory problems. In addition, people who have frank memory problems, probably related to mild Alzheimer-type problems, are also sought.

Your task in this project will be to do some simple tests of your ability to discriminate between patterns of dark/light objects and to remember the pattern over brief delays (3 or 12 seconds). Some trials will have simple activities to perform during these delays.

Some basic questions pertinent to Alzheimer's disease will also be administered.

There are no risks involved in the performance of the tasks. The tests are not related to intelligence or personality; they simply provide an index of ability to discriminate and remember visual patterns. Adequate rest breaks will be provided to prevent fatigue.

Your identity and resulting scores will remain confidential at all times. Only you and the researchers will have access to your scores. Your identity will be coded so that any report of the scores obtained cannot be traced back to any subject by an outsider. Results of this project will be used for a thesis by the researcher and may be published in the scientific literature.

Your participation in this project is completely voluntary, and you are free to withdraw from the project at any time.

Testing will be spread over three sessions of about one to one and a half hours each.

The project is being carried out by Ms. Joyce Majendie under the supervision of Dr. John Dalrymple-Alford. She will be pleased to discuss any concerns you may have about participation in the project (ph 3322706).

This project has been reviewed and approved by the University of Canterbury Human Ethics Committee.